Geographical Distribution of Childhood Acute Leukaemia in the Metropolitan Area of Guadalajara, Mexico and Its Correlation with the Wireless and High Voltage Network

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Abstract— This first study conducted by the University of Guadalajara, the Pediatric National Social Security Medical Center, the Hospital Civil de Guadalajara and the General Hospital of Guadalajara, shows the geographical and temporal distribution of 269 cases of children suffering from leukaemia in 6 municipalities in the metropolitan area of Guadalajara (2014). In Mexico, geographical information systems (GIS) have been rarely implemented to monitor spatial assessments of leukaemia. We present an analysis of the spatial distribution of acute leukaemia among children from 0 to 16 years of age in the metropolitan zone of Guadalajara, Mexico using individual case hospital data from the three main hospital facilities treating this population.

Methods: Using the approach of spatial epidemiology DBSCAN and 1-dist, cases of leukaemia obtained from the databases of hospitals resulted in "clusters" or groups of cases/100,000 inhabitants. Cancer cases were grouped according to an internationally recognized morphology.

Results: The results show the occurrence of 94 cases of leukaemia along the deployment path of high voltage electricity, or 36% of all reported cases are located less than 100 meters in distance from a distribution line and other results shows 24 cases/100,000 inhabitants for leukaemia (acute lymphoblastic leukaemia) LLA and 4.4 cases/100,000 inhabitants for leukaemia AML (acute myeloid leukaemia). These resulting measurements exceed international norms. The values are usually 3–5 cases/100,000 for LLA and 0.8 cases/100,000 for AML.

Conclusions: Although the etiology of most childhood leukaemias is unknown, there is a significant correlation between spatial disease cluster (with an unusually elevated disease incidence rate) and both the high voltage distribution network and the wireless communication network. Studies in the literature have focused on childhood leukaemia because of its relatively large incidence among children compared with other malignant disease, its apparent tendency to cluster, and the public concern over locally elevated leukaemia incidence.

1. INTRODUCTION

Undoubtedly the ability to generate electricity and distribute it for use in daily life has been one of the greatest inventions in the world. With this, humankind has taken a giant leap in its development and welfare Fig. 1. Carrying out these processes, however, has brought health risks; some risks are very obvious, such as the risk of being electrocuted. Other risks are not so obvious but still significant, such as the risk associated with non-ionizing radiation produced by the electromagnetic field that always accompanies electricity [12].

Non-ionizing radiation and its effects are not new; however it was not until a few years ago when discussions of this type of radiation became more intense as it was considered to have harmful effects on human health. It increased on one hand the risk to people who constantly use information technology devices, without control and without precaution, and on the other hand the risk to users and/or people living close ($< 100\,\mathrm{m}$) to high voltage power distribution lines generating very large electromagnetic fields at low frequencies [1, 12].

It has long been observed that scientists and experts have written about precautionary principles to be implemented among the population against non-ionizing radiation in the environment, but in

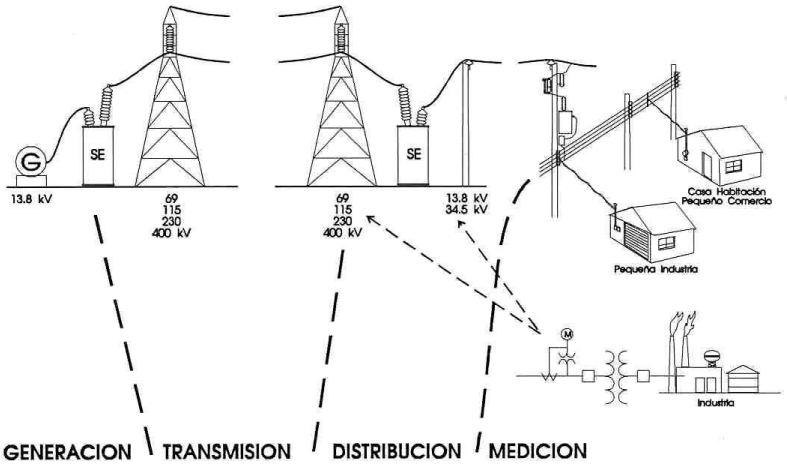

Figure 1: Process of production, transmission and distribution of electrical energy in Mexico.

many countries, including Mexico, people have ignored these precautions, giving greater importance to the benefits of "access", "mobility", "comfort" and "services", putting the safety of their population at risk. On the other hand we must add that the modern services that telecommunications provides us are very profitable and are very necessary for the development of a country [2].

The World Health Organization (WHO) has already spoken in respect, supporting the recommendations of the International Commission on Non-Ionizing Radiation (ICNIRP International Commission on Non-Ionizing Radiation Protection, 2009; WHO, 2013) [3].

This paper shows the geographical distribution of cases of acute lymphoblastic leukaemia (ALL) and acute myeloid leukaemia (AML) and their relation to high voltage distribution lines in 6 municipalities of Greater Guadalajara.

2. BACKGROUND

Although we do not yet understand the causes, researchers have studied a number of possible explanations including genetic susceptibility, ionizing radiation, unusual patterns of exposure to infection, and non-ionizing radiation received from low frequency electromagnetic fields [4].

In some studies, it is said that about one child in every two thousand contracts leukaemia before the age of 15 years [5]; the equivalent study conducted in the Guadalajara Metropolitan Area found the number in this context to be five times higher [6]. This topic is very complex because although there is a great deal of research globally and a substantial amount of contributions concerning the process of how a child contracts acute leukaemia, we are still far from having causal conclusions about possible contaminants that could be the spark.

The rapid population increase in many cities in Mexico has created a disarray in the penetration of electricity services, lacking proper planning in distribution, resulting in dwellings that are literally situated below power lines. In addition, a lack of order in other services such as potable water distribution, and the mismanagement of organic waste in the population create the ideal stage for the appearance of disease, whether gastrointestinal or more serious, such as acute leukaemia [6].

Some studies report that 1.30% of cases of childhood leukaemia may be associated with power lines [6]. Other studies have shown that children living within a range of less than 200 meters of high-voltage lines have a risk as high as 70% of contracting leukaemia compared with children living beyond 600 meters [1]. In this study we obtained a geo-referenced census of acute leukaemia, resulting in a suprisingly large number of cases of leukaemia around certain residential areas. We obtained groupings of up to 16 cases of acute leukaemia in an area smaller than 10 square kilometers, with distances less than 1 kilometer between each case of leukaemia. Since 2001, the International Agency for Research on Cancer has classified extremely low frequency magnetic fields as "possibly carcinogenic"; as a result there are many studies trying to assess the risk factors [11].

The most important and striking part of this research was the large number of cases of leukaemia /inhabitants found in so little space. The source of information comes from three major hospitals in the city. On average, each hospital treats up to 80 cases per year of acute leukaemia in children younger than 14 years of age [5, 8].

3. METHODOLOGY

I. For the first stage, a geo-referenced census of cases of lymphoblastic leukaemia and acute myeloid leukaemia was created for the first time in Mexico in the metropolitan area of Guadalajara, yielding a sample that represents 95% of all cases (Fig. 2).

II. In the second stage, a study geo-referenced to the high voltage lines within the metropolitan area of Guadalajara was conducted (Fig. 3).

III. The third stage was an analysis of cases of leukaemia near high voltage lines and a study of the associated pattern (Fig. 4).

Figure 2 shows a map of the Guadalajara metropolitan area and the geographic distribution of 268 (representing 95% of the total) cases of children suffering from any of two cases of acute leukaemia: 227 cases of acute lymphoblastic leukaemia and 42 cases of acute myeloid leukaemia. Using the concept of AGEB[1] or Agglomeration Geographic Basic Statistics proposal for population studies, with support from the National Institute of Statistics, Geography and Informatics (INEGI) [4], the results showed 24 cases/100,000 for acute lymphoblastic leukaemia and 4.4 cases/100,000 for acute myeloid leukaemia. The comparison with global benchmarks indicates that there is a major problem, since the usual incidence of acute lymphoblastic leukaemia is 3–5 cases/100,000, and of acute myeloid leukaemia 0.8 cases/100,000.

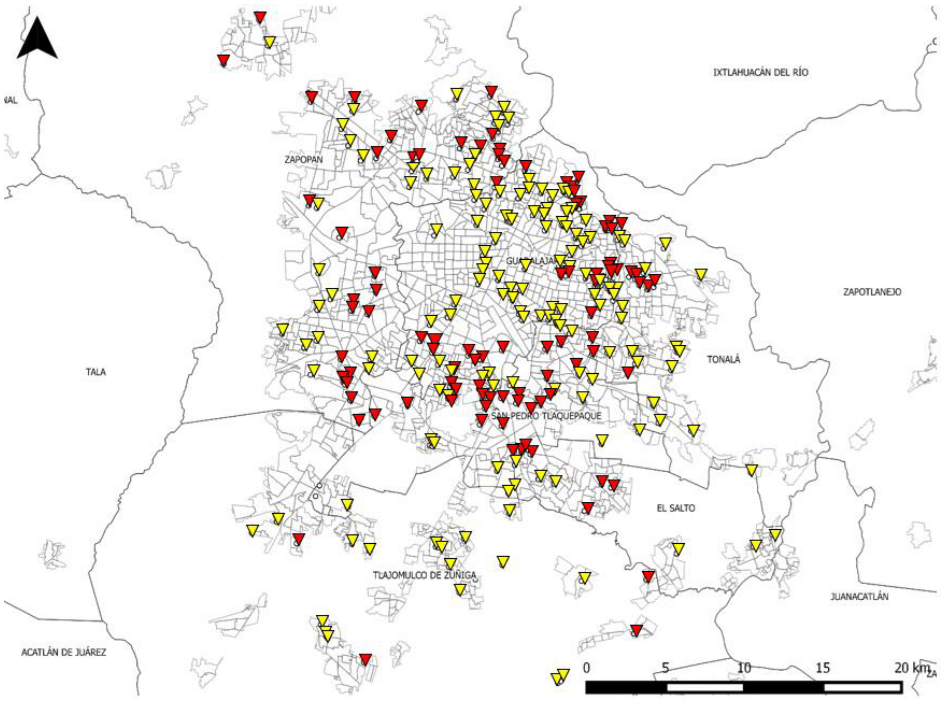

Figure 2: Cases of acute leukaemia in the population aged 0–14 years in the Guadalajara metropolitan area.

Figure 3 shows a map of Guadalajara and its metropolitan area, with corresponding routes of high voltage lines provided by the government enterprise Federal Telecommunications Commission (CFE). These routes show the high penetration of high voltage in the inner city. The characteristic of these lines is that they are unprotected elevated lines. The rapid pace of growth in the city of Guadalajara and its metropolitan area, along with extreme poverty generated in the last 20 years in the country, has lead to the presence of many dwellings aside high voltage routes (closer than 30 meters). In marginalized areas such dwellings are literally adjacent to these lines (less than 15 meters). This is the reason why this study proposes to find a pattern among the high voltage routes and the number of cases of leukaemia in children under 14 years of age.

[1] Agglomeration Geographic Basic Statistics (AGEB). Branch municipalities or delegations that make up the country, first used in the Tenth General Census of Population and Housing, 1980 (INEGI) [4]. Its usefulness lies in allowing the formation of primary sampling units and the organization of statistical information. It has three main attributes: (a) it is easily recognizable in the field to be bounded by identifiable and enduring topographic features; (b) it is generally homogeneous in terms of geographical, economic and social characteristics; (c) the extension is such that it can be covered by a single person.

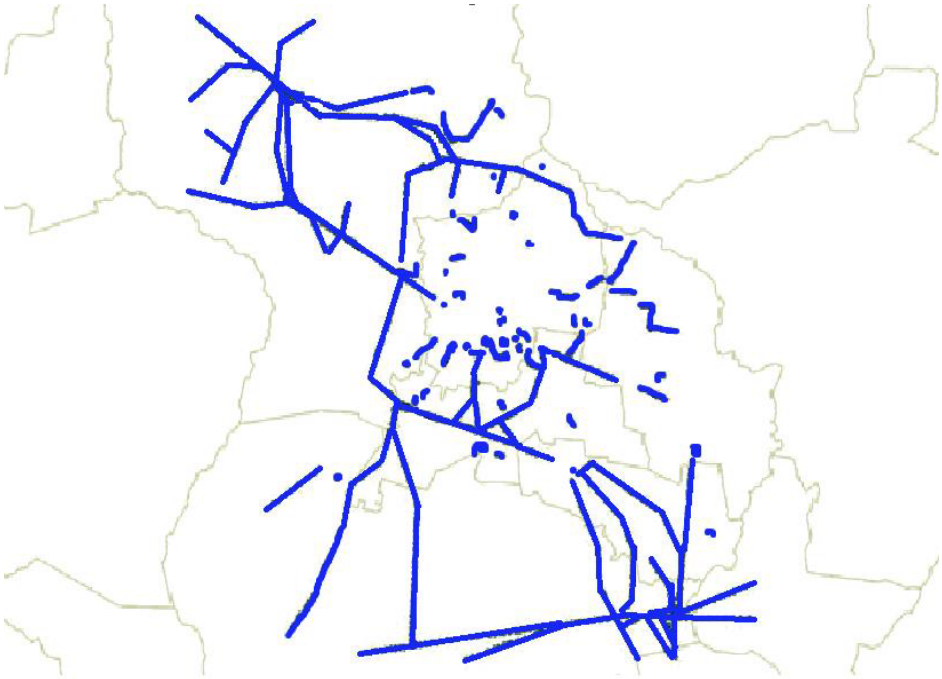

Figure 3: Routes of high voltage electrical distribution lines in the Guadalajara metropolitan area.

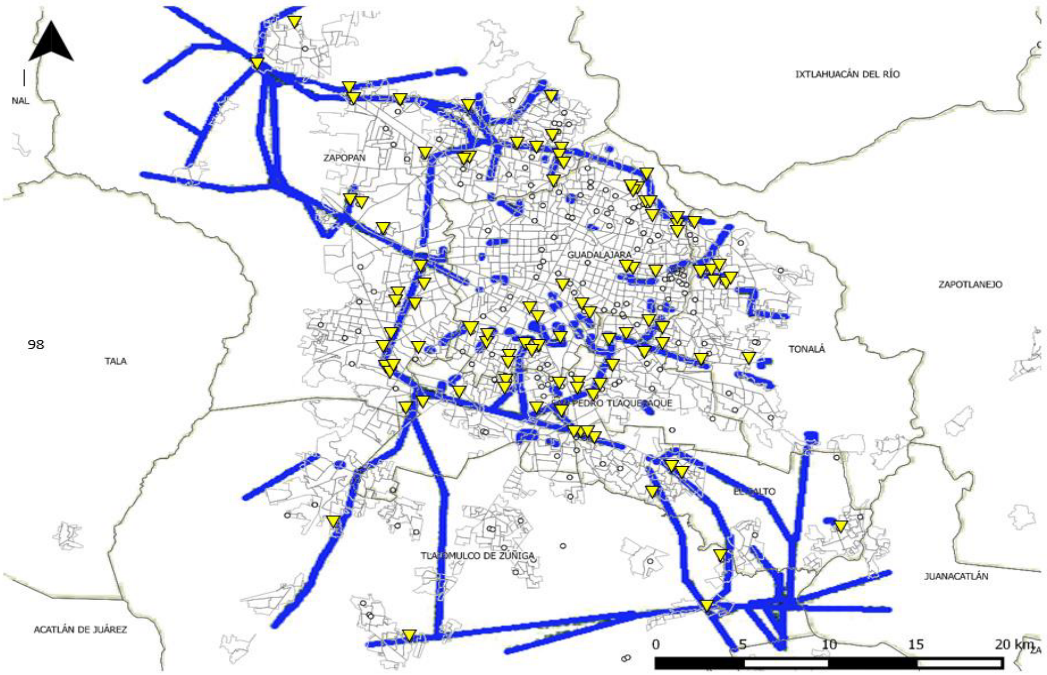

Figure 4: Cases of leukaemia along the lines of electrical power distribution.

Figure 4 shows a map of the Guadalajara metropolitan area and the geographic distribution of all cases of acute leukaemia and high voltage routes. A filter was applied, showing only the cases that are within a distance of 100 meters of a high voltage route.

4. RESULTS AND DISCUSSION

In the first stage the geographical distribution of 269 (representing 95% of the total) cases of children suffering from any of the two cases of acute leukaemia was obtained. Using the concept of AGEB or Agglomeration Geographic Basic Statistics proposal for population studies, with the support of the National Institute of Statistics, Geography and Informática (INEGI), the results

yielded 24 cases/100,000 for acute lymphoblastic leukaemia and 4.4 cases/100,000 inhabitants for acute myeloid leukaemia. The comparison with global benchmarks indicates that there is a major difference, since the usual incidence of acute lymphoblastic leukaemia is 3–5 cases/100,000, and of acute myeloid leukaemia 0.8 cases/100,000.

In the second stage the results show the occurrence of 94 cases of leukaemia along the deployment path of high voltage electricity, or 36% of all reported cases are located less than 100 meters in distance from a distribution line. In previous studies [10] conclusions were that living near a distribution line increased the risk of contracting a type of leukaemia by a factor of 3. In the present work only the two most frequent types of leukaemia were analyzed.

These results show that the investigation of cases of acute leukaemia in children and its co-relation to non-ionizing radiation, either low or high frequency, has just gotten off the ground. With future studies, it will be important to estimate the disease burden of this type of pollution.

5. CONCLUSIONS

While there is no proven cause and effect relationship of non-ionizing electromagnetic radiation from high voltage power sources at low frequency on human health, it is interesting to note a pattern associated with up to 30% of all cases of leukaemia and the deployment of high voltage power line; there is even a case in which 3 sources of high voltage power lines merge.

ACKNOWLEDGMENT

We thank the directors of the following hospitals, all located in the metropolitan Guadalajara area, for help in the use of their databases: the Decentralized Public Agency Civil Hospital, the Pediatric Hospital of the IMSS National Western Medical Center, and the General Hospital of Guadalajara.

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